Jun 5th, 11:00 AM

Mars Exploration

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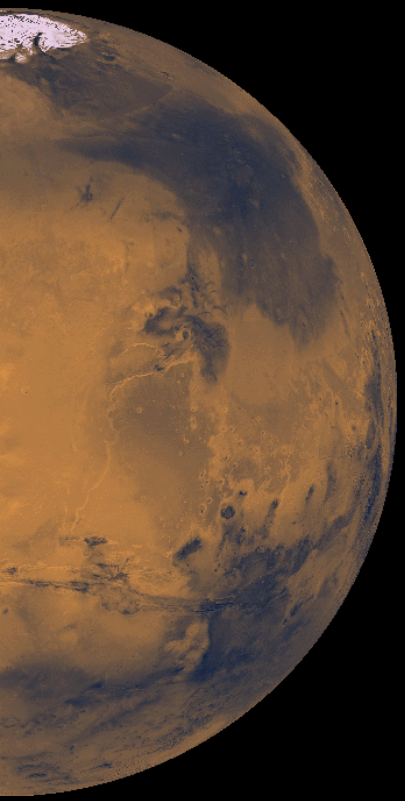

Mars Exploration

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California Institute of Technology


MARS MISSIONS
OPERATIONAL 2001–2017
FUTURE 2018–2030
Mars Express (ESA) (2003)
Mars Odyssey (2001)
Mars Reconnaissance Orbiter (2005)
MAVEN (2013)
Mars Orbiter Mission (ISRO) (2013)
Trace Gas Orbiter (ESA/RSA) (2016)
HOPE (UAE)
MMX (JAXA)
Mars Orbiter (China)
Mars Lander & Rover (China)
Planning MSR
Opportunity Rover (2003)
Curiosity Rover (2011)
InSight
Mars 2020 Rover (NASA)
ExoMars Rover (ESA/RSA)
Mars Sample Return (China)
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Overview of Mars Exploration

Jet Propulsion Laboratory
California Institute of Technology

Scientific Findings:

- Mars was once habitable—was it ever inhabited?
- Water flowed on and beneath the Mars surface intermittently over the first half of the planet's history.
- Mars has lost ≥ 70% of its ancient atmosphere and most of its water.
- Mars has resources: Ice, hydrated minerals, CO_2.

Engineering:

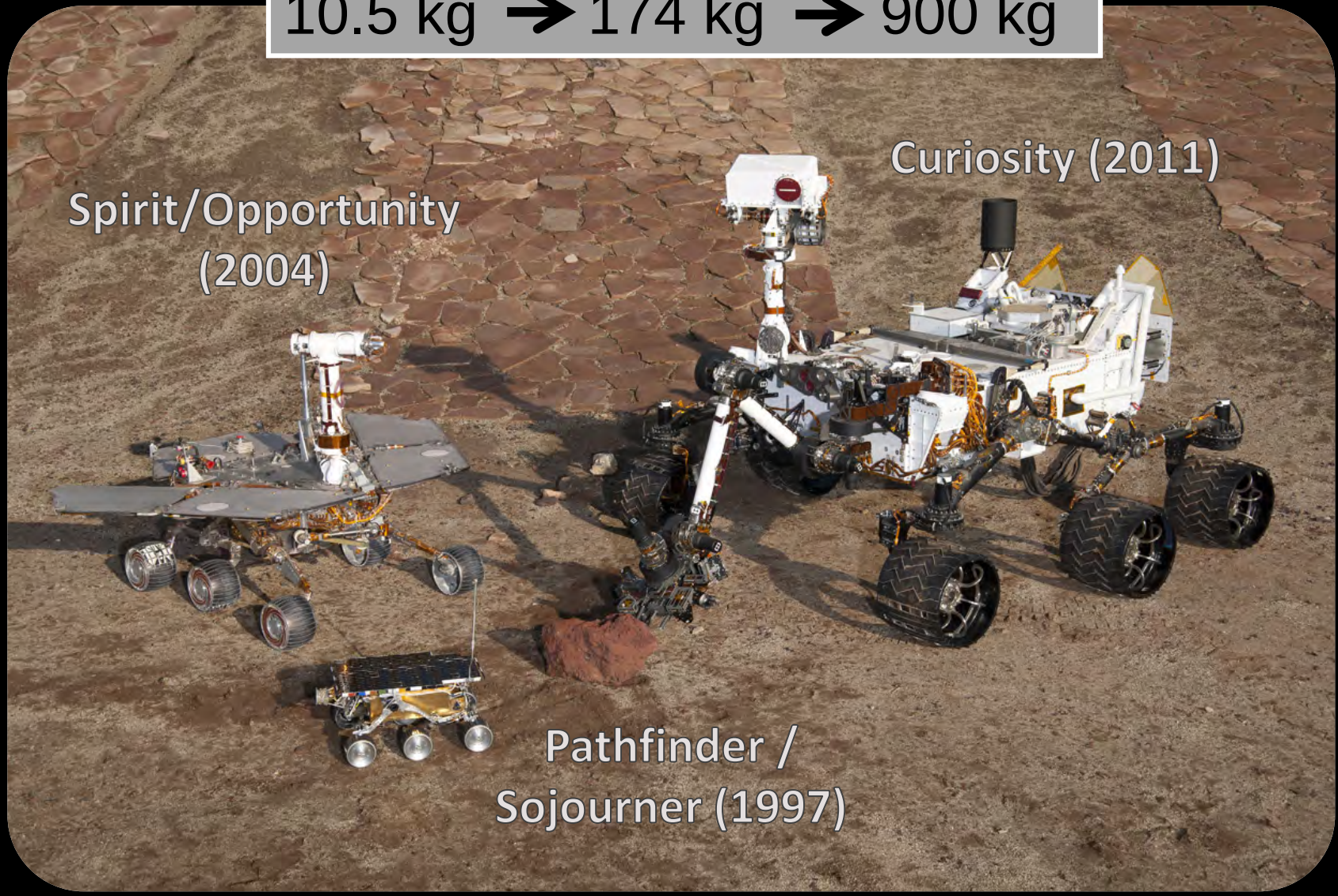
- Improved delivery systems bring heavier spacecraft more precisely to the surface.
- Surface mobility brings access to a diverse environment.
- Autonomy (e.g., visual odometry) increases safe driving range.

Operations:

- Orbital relay infrastructure enhances data return from surface assets.
- Long duration missions enhance overall mission return.
- Complex operations (e.g., drilled samples analyzed onboard) have been conducted.

Evolving Rover Capability

10.5 kg → 174 kg → 900 kg



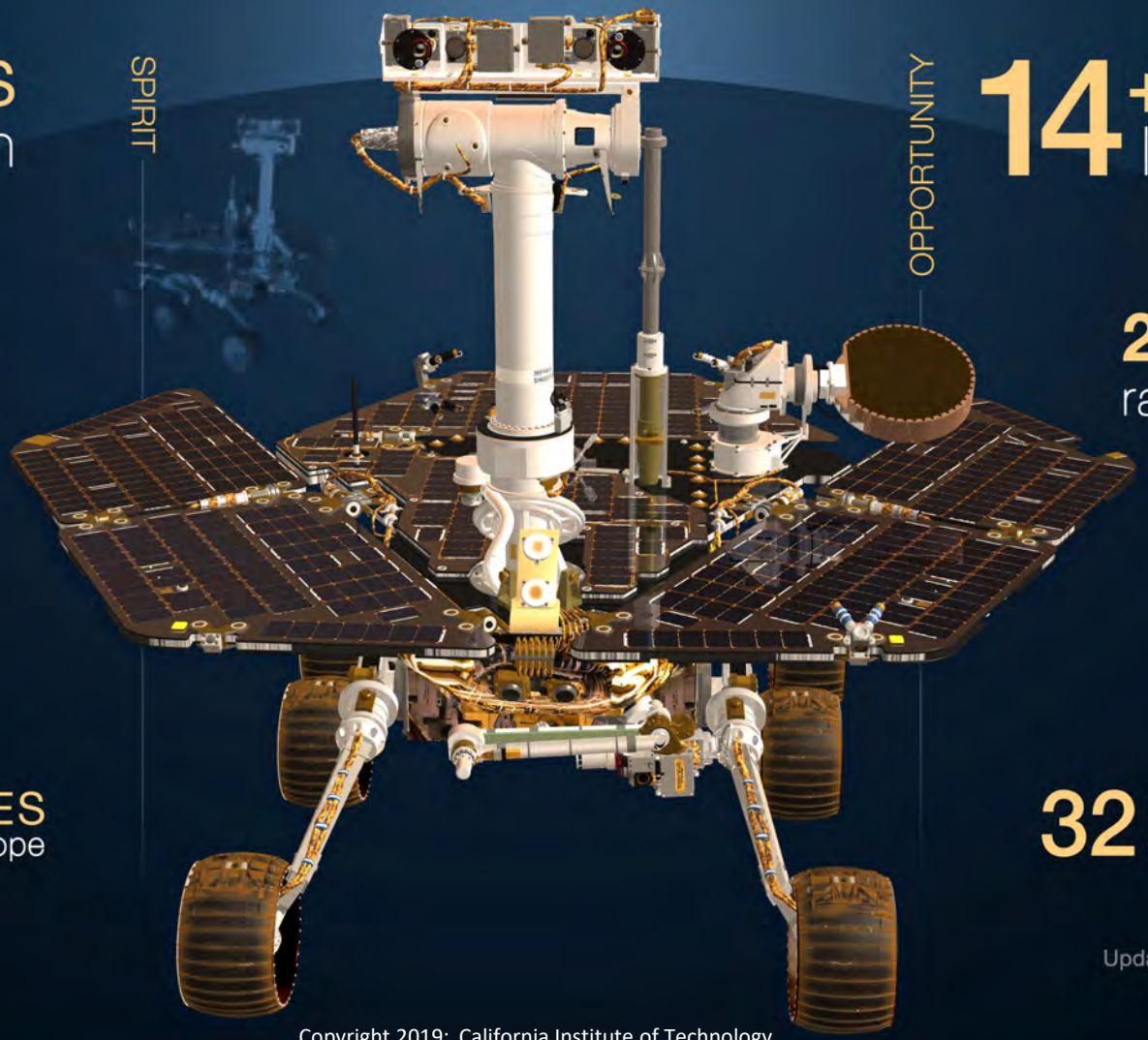
Pathfinder Sojourner: First Rover on Mars

- Landed July 4, 1997
- Ares Vallis, Mars
  - An ancient flood channel
- Solar powered vehicle
- Communicated with Earth thru Lander
- Alpha Proton X-Ray Spectrometer

MER – 2nd Generation Mars Rover

Spirit and Opportunity

BY THE NUMBERS



6 YEARS lifespan

124,838 raw images

4.8 MILES traveled

30 DEGREES steepest slope

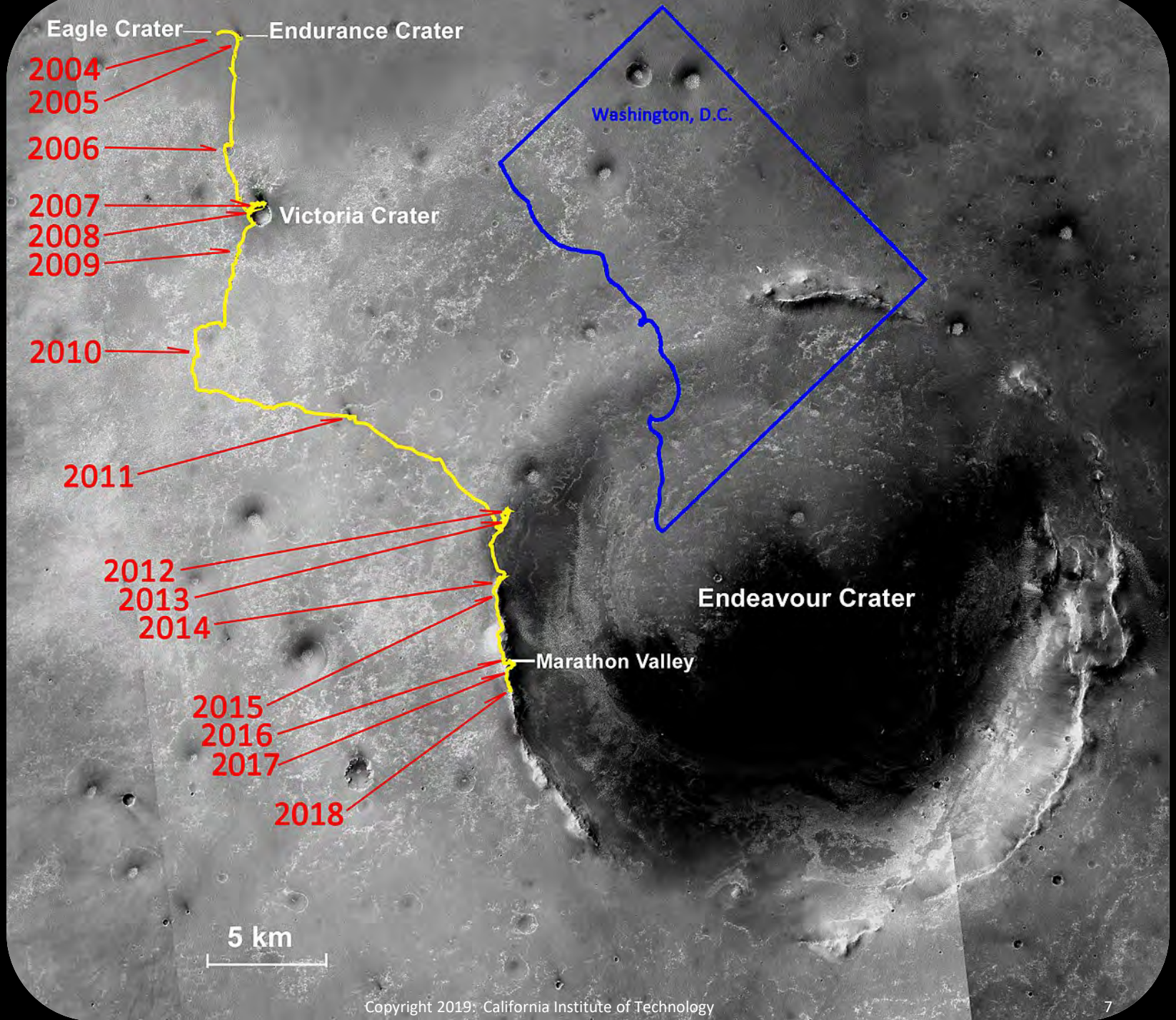
14+ YEARS lifespan

217,594 raw images

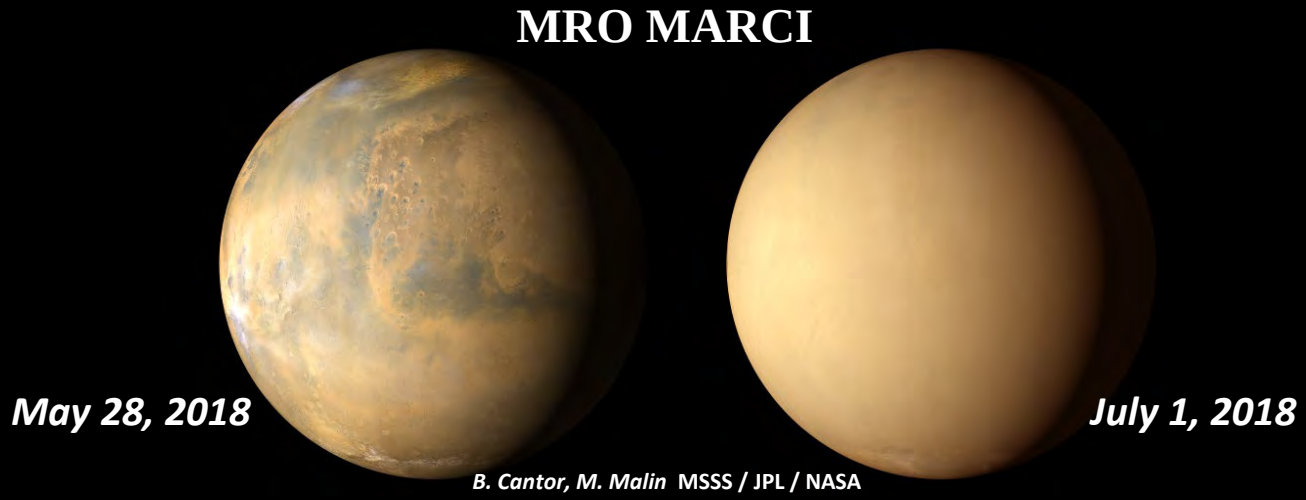
28 MILES traveled

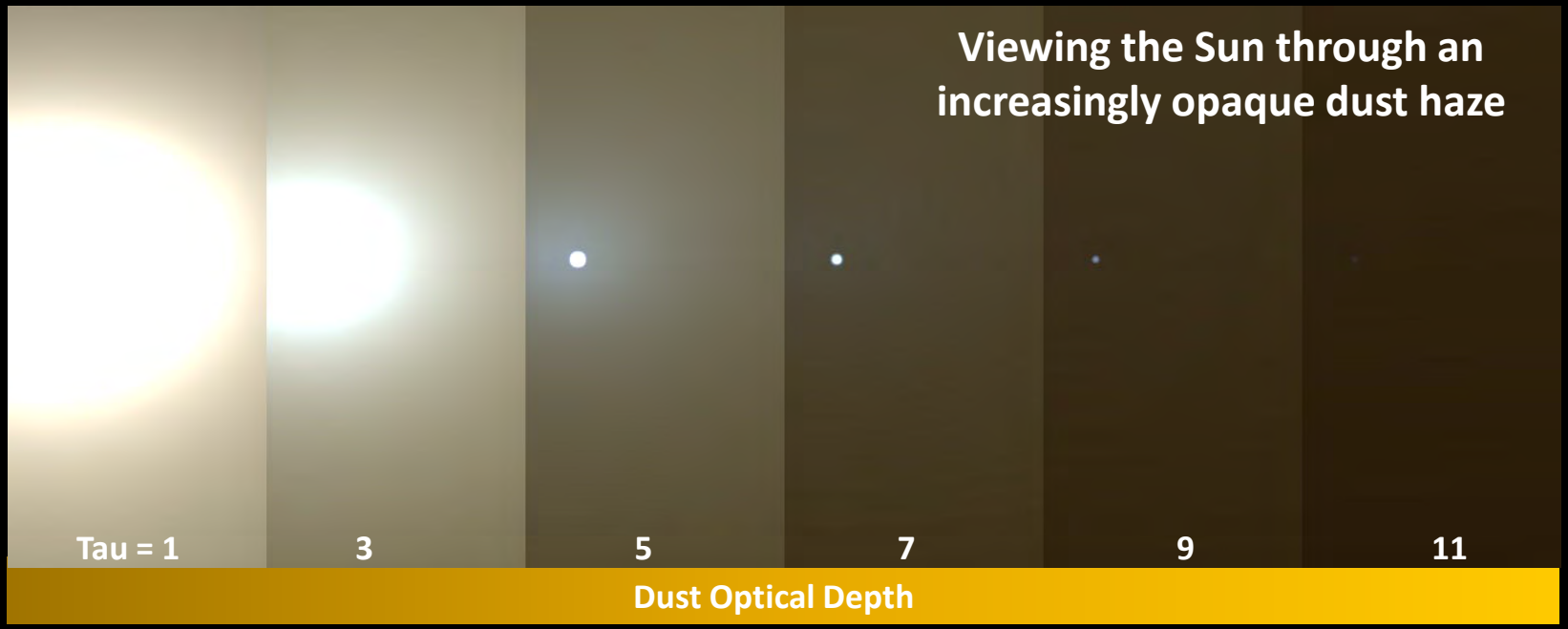
32 DEGREES steepest slope

Updated February 4, 2019



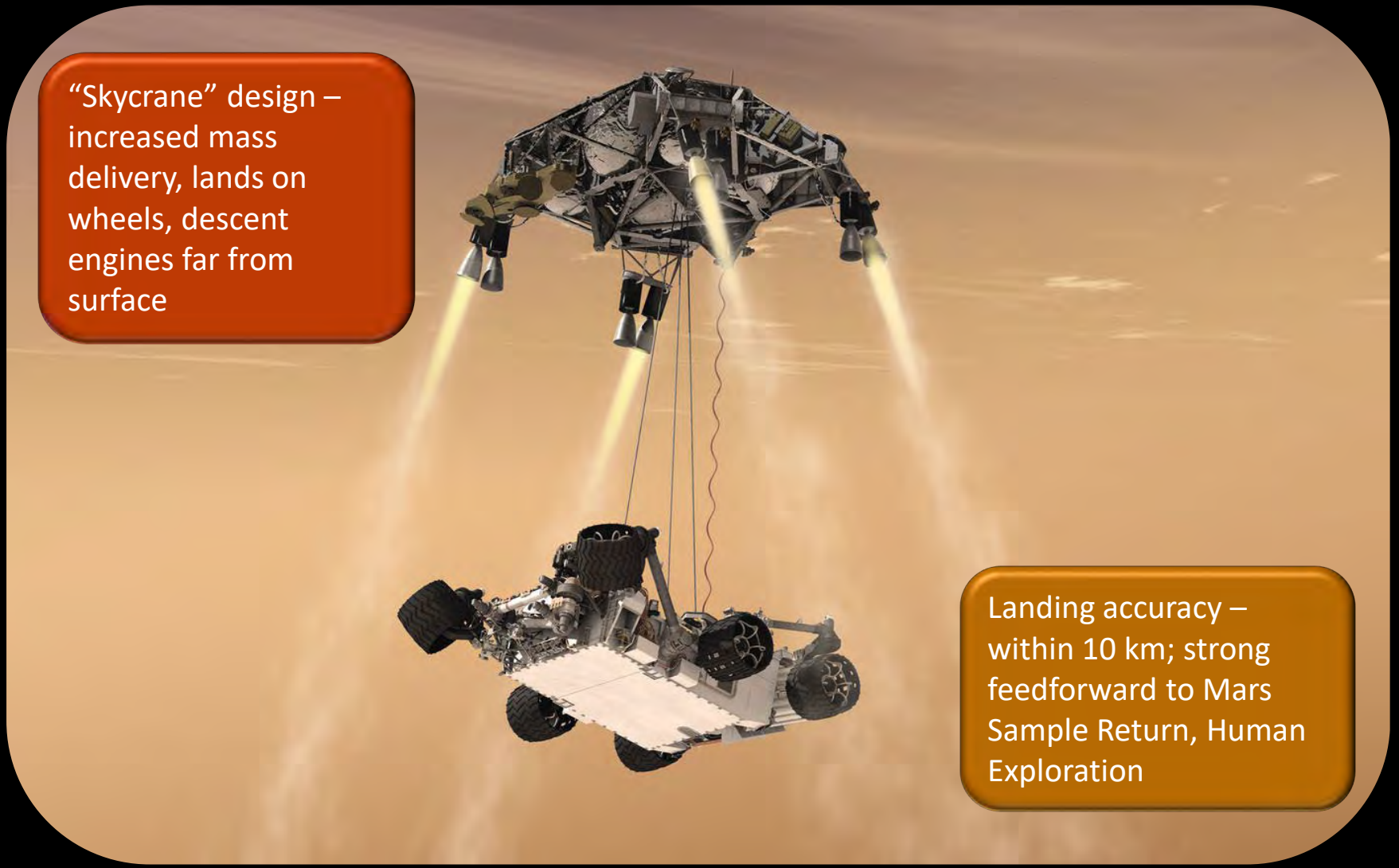
The 2018 Planet Encircling Dust Event





Lemmon, MER-Opportunity Science Team

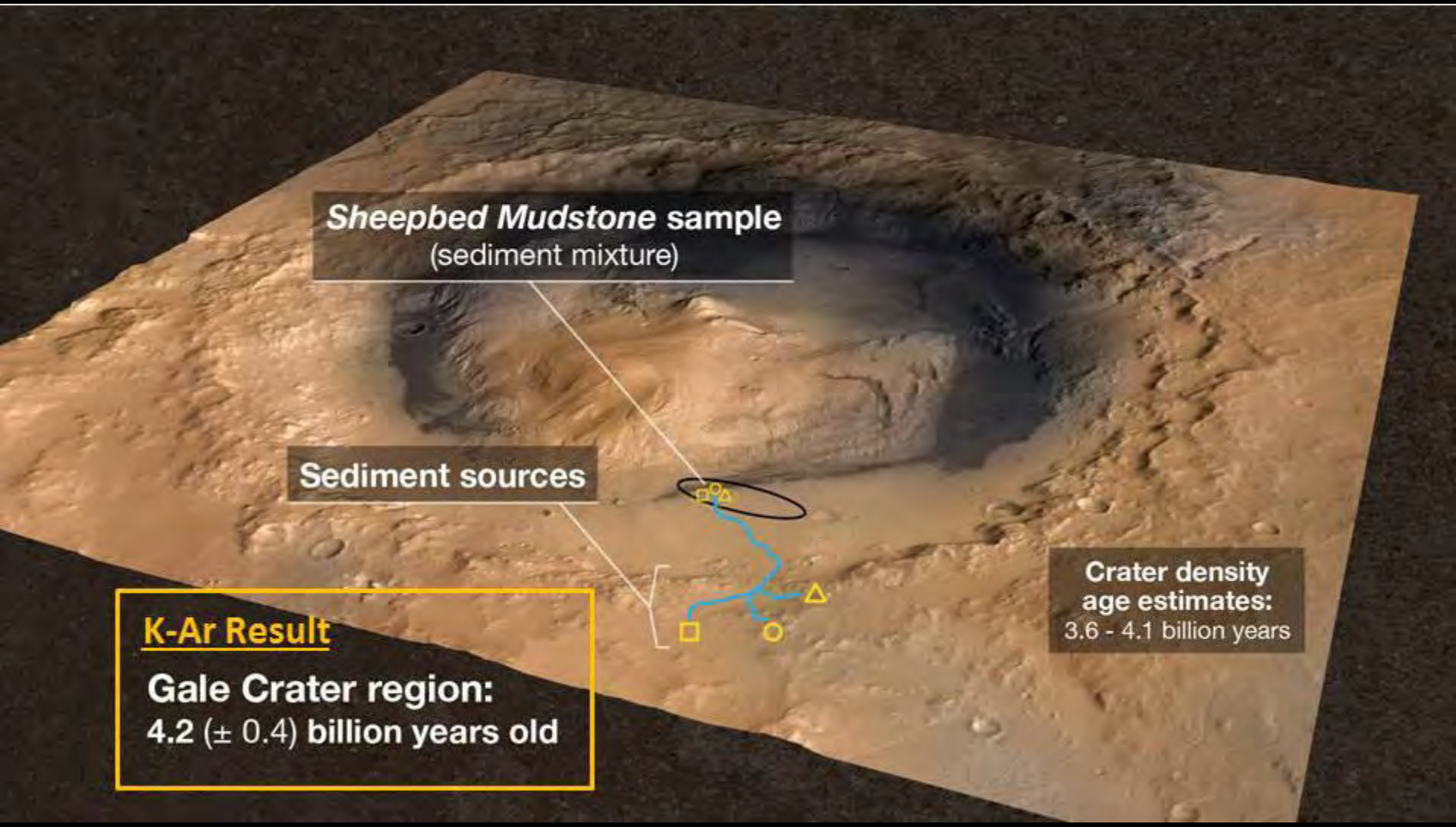
Curiosity – 3rd Generation Mars Rover



"Skycrane" design – increased mass delivery, lands on wheels, descent engines far from surface

Landing accuracy – within 10 km; strong feedforward to Mars Sample Return, Human Exploration

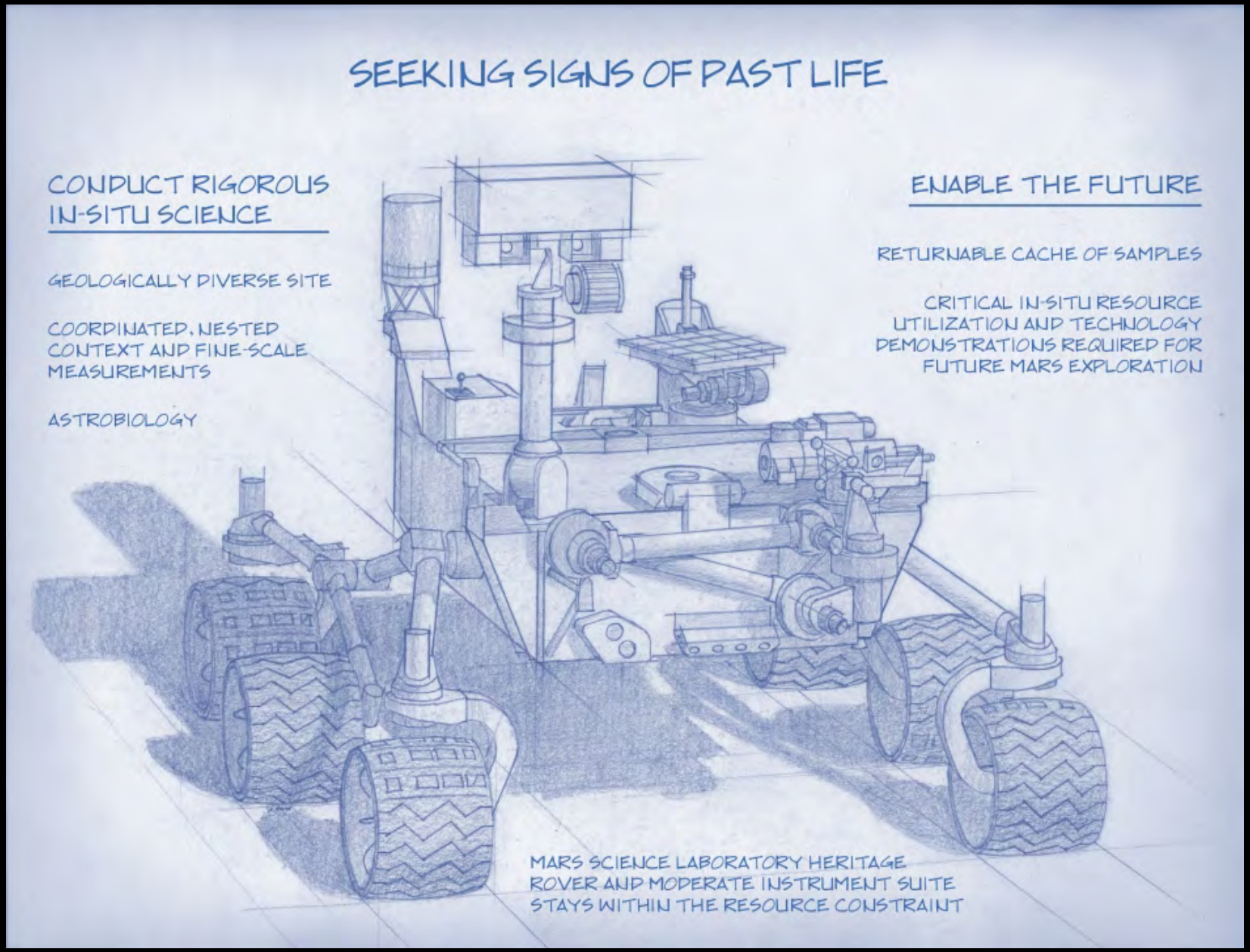
Curiosity Lands at Gale Crater



Curiosity at Vera Rubin Ridge

Background image: NASA/JPL/MSSS/National Geographic

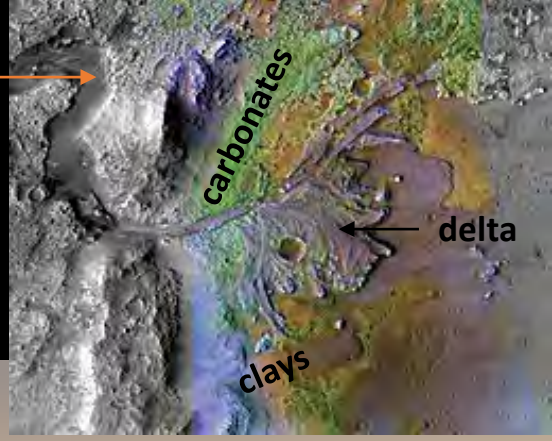
Mars 2020 – Gathering Samples for Possible Return



M2020 landing in Jezero Crater in 2021

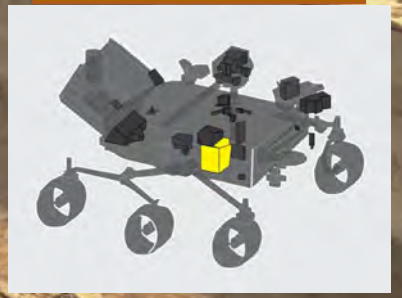
Mars 2020 will carry ~40 total sample tubes with ~20 to be filled in a 1-Mars year primary mission

Sample Return Tube



Mineralogy from MRO CRISM
NASA / JPL / JHUAPL / MSSS / Brown U.

MOXIE: Mars Oxygen In-Situ Utilization Experiment



Artist's Conception: M2020 on the Floor of Jezero Crater

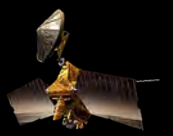
Notional Mars Sample Return Architecture

- "Focused" Sample Return: Three flight elements plus one ground element
  - Capitalize on existing assets and past experience
  - **Focused scope** on 2011 Decadal Survey top flagship priority
    - Payloads focused on MSR objectives; may be secondary launch opportunities
  - Build on technology investments (e.g., Mars Ascent Vehicle)
  - Leverage partnerships (e.g., the recent NASA-ESA Statement of Intent on MSR)

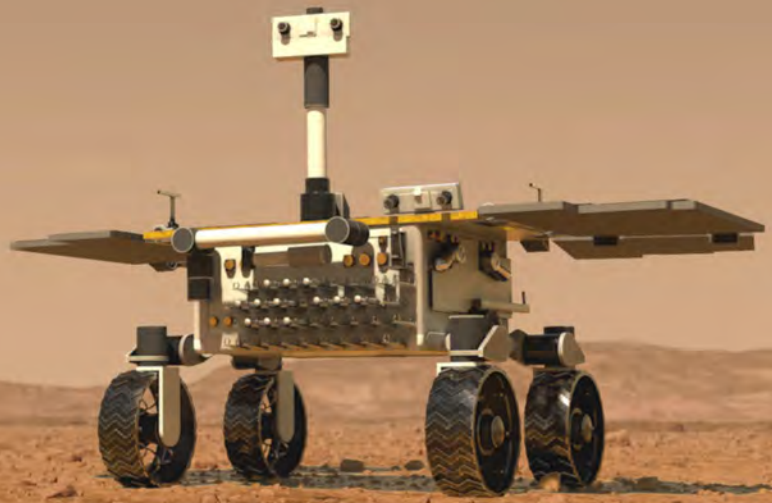
Sample Caching Rover	Sample Retrieval Lander	Earth Return Orbiter	Mars Returned Sample Handling
(Mars 2020)	*Fetch Rover*	*Rendezvous and On-Orbit Capture System*	•*Sample Receiving Facility*
Sample acquisition and caching	*Orbiting Sample container (OS)*	*Earth Entry Vehicle*	•*Curation*
	Mars Ascent Vehicle		•*Sample science investigations*

Flight Elements | ***Ground Element***

Looking Ahead



- Continue the ongoing scientific exploration of Mars while preserving the infrastructure needed to support future missions



- Get Mars 2020 launched and safely operating on Mars
- Support the next steps in the potential Mars Sample Return campaign

- Provide information for the design and operations of future missions supporting exploration by humans *on* Mars